New concept for single molecule transistor

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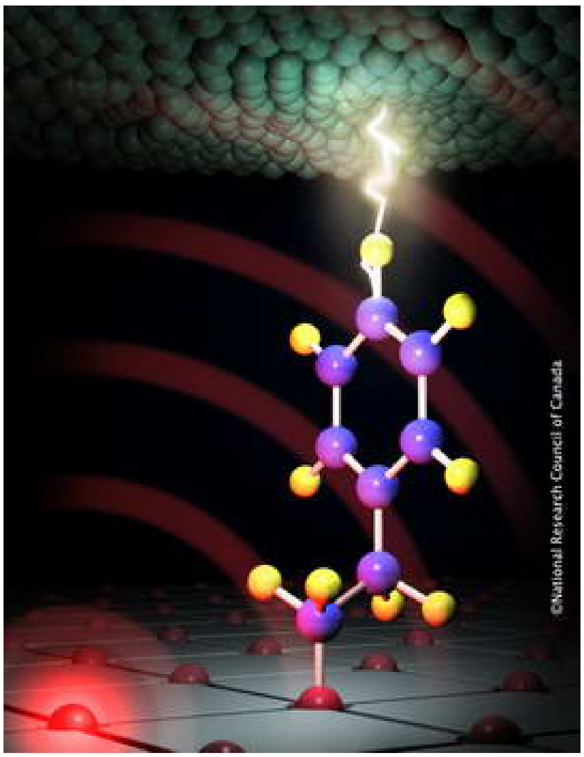

Molecular electronics â€“ using molecules in the construction of electronic circuitry â€“ just took a significant step closer to reality. Principal investigator Dr. Robert Wolkow, postdoctoral fellow Dr. Paul Piva and a team of researchers from the National Institute for Nanotechnology of the National Research Council and University of Alberta have designed and tested a new concept for a single molecule transistor. They have shown, for the first time, that a single charged atom on a silicon surface can regulate the conductivity of a nearby molecule. Their discovery is published in the June 2, 2005 edition of the scientific journal *Nature*.

Image: Electric field emanating from the charged red atom causes energy level shifts in the molecule allowing current to flow. (Courtesy of the National Research Council of Canada)

Miniaturization of microelectronics has a finite end based on todayâ€™s technology. To continue, a new concept was needed which circumvented the limits of conventional transistor technology. The authors conducted an experiment to examine the potential for electrical transistors on a molecular scale. Their approach has solved what has been an insurmountable hurdle to making a molecular device â€“ getting connections onto a single molecule.

They demonstrated that a single atom on a silicon surface can be controllably charged, while all surrounding atoms remain neutral. A molecule placed adjacent to that charged site is â€˜tunedâ€™, which allows electrical current to flow through the molecule from one electrode to another. The current flowing through the molecule can be switched on and off by changing the charge state of the adjacent atom. The results are promising and are considered to be a scientific breakthrough.

â€œWe have shown the potential for devices of unheard-of smallness and unheard-of efficiency.â€? says Dr. Wolkow. â€œA technology based on this concept would require much less energy to power, would produce much less heat, and run much faster.

Molecules are exceedingly small, on the scale of a nanometre. Wolkowâ€™s team solved the connection problem by using the electrostatic field emanating from a single atom to regulate the conductivity of a molecule, allowing an electric current to flow through the molecule. These effects were easily observed at room temperature, in contrast to previous molecular experiments that had to be done at temperatures close to absolute zero in order to measure a conductivity change. Another significant aspect of this breakthrough is the fact that only one electron from the atom is needed to turn molecular conductivity on or off. On a conventional transistor, this gating action requires about one million electrons.

â€œThis concept could circumvent the limits of conventional transistor technology and permit miniaturization on a nanometric scale. Betterâ€¦fasterâ€¦cheaper â€“ thatâ€™s the promise of molecular electronics. In our case, we also have a potentially powerful green technology because of its minimal power and material requirements, and the biodegradable nature of the device.â€?

Wolkow, a world-renowned researcher in nanotechnology, says that although his results represent a key step toward molecular electronics, more steps are required. He advocates doing research on hybrid molecular/silicon devices. â€œThis way, we can piggyback on all the great capacity that has already been established for silicon, and just supplement it. Our prototype works on silicon â€“ thus allowing the old technology to merge with the new. â€œ

â€œI am optimistic that molecular electronic devices can be made using our method because I donâ€™t see a reason why the remaining hurdles canâ€™t be overcome. And given the promise of such devices â€“ great speed, small size, and high efficiency â€“ the hurdles are definitely worth tackling.â€?

Publication:
Field Regulation of Single Molecule Conductivity by a Charged Surface Atom
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